SCIENCE

NEW SERIES
VOL. XLV. No. 1172

FRIDAY, JUNE 15, 1917

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $5.00

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-On-Hudson, N. Y.

THE RELATION OF WAR TO CHEMISTRY IN AMERICA[1]

WAR is an evil beyond the power of language to express. To kill one's neighbor or one's enemy is so repellent a thought that one cries out in horror at the idea and instinctively wants to refuse to have any part in action or government which involves such baseness irrespective of the provocation. It is only with the greatest difficulty that we persuade ourselves to act together in any such capacity except in spontaneous defense. Were it not for the religious emphasis upon our duty to support the civil magistrate in the execution of righteous law, and therefore to resist aggression against such law, we would find little ground to stand upon in our present crisis, except it be the desire to bring annihilation upon the philosophy which gave rise to this world war.

It has become more and more apparent that we have been dealing with a power in the case of Germany that is as unscrupulous as her acts are unmanly and cruel, and that the complaints of her opponents against her since 1870 have probably not been overdrawn. The pall of horror and indignation which fell upon us during the invasion of Belgium and France was relieved when the Marne gave hope that there was still power enough in the world to frustrate the dream of the bully. This pall has been slowly growing upon us again, however, in spite of the persistent efforts of the German propaganda amongst us to conceal and belie the reports of the damnable conduct of their armies and government at

[1] The annual address before the Ohio Academy of Science, Columbus meeting, April 6, 1917.

home and in the hapless countries for a time at their mercy. Because of these things we see men everywhere bowed down and depressed as it becomes clearly demonstrated that science, mental endowments and education are no specifics against a wicked heart. These things we really knew before but refused to believe. They are demonstrated to us now by appalling examples so that the whole thinking community has become so mentally and spiritually depressed that one has great difficulty in going about one's normal work, health is damaged and continued research is a matter of great difficulty. A nation of unusual opportunities, great mental endowment and development in science seems to have become the willing or at least easily manipulated pawn in the hands of the unscrupulous statesman. We have not forgotten that it was a chemist, Ostwald, in the early days of the war, when he was acting as a spokesman for Germany to men of science throughout the world who was quoted, when Germany was in the flush of her initial victories over Belgium, as saying the world had outgrown the idea of freedom for little or weak peoples.

War, therefore, is a universal mental depressant and as such, alone, must damage progress in science. It saps national energy and material resources. It destroys the life of the younger generation of scientists and, in large part, the student material from which the scientists of the future are recruited. It interferes with systematic research in many lines by mentally depressing the workers, placing insuperable difficulties in their path and at times by destroying priceless work, records and literature. Certainly war is not desirable to science, even if we could restrain our detestation of it and all its works.

Bitterly as we may condemn war, we should be wrong, however, to claim that science stagnated or declined in war time. Since war requires brains, science is of course utilized, and since the demand is inexorable, science must produce, and when science and engineering are producing, they grow. We have come to learn that modern war is a scientific business undertaking. It involves the use of all vital human endeavors, and therefore to varying extent, of all applied science. On the one hand, it involves the utilization of medical science to maintain physical efficiency and speedily repair damage to the fighting machine. On the other hand, it involves the utilization of agricultural, physical and chemical science in feeding and clothing the whole military and naval establishment, and manufacturing the equipment, armament and "concentrated energy" or explosives consumed by the fighting force. It is stated that it requires three men in the shops to maintain one man in the army and seven men for one in the navy. It is evident therefore that it is the applied portions of science that are most used and hence that grow most under war's influence. It is common experience, however, that the stretching into new domains and the striving for new goals by applied science, enriches the feeding ground of unapplied science and uncovers fertile fields for the patient and quiet research which follows and which often becomes the very backbone of science itself. These results are scarcely visible and will not mature in any event, for years after the war, so that we can see at present little good effect upon unapplied science and we feel quite certain that the reverse influences have the upper hand.

Although it would not be wise at present even if we had the time to go into detail in discussing this subject nor would it profit you particularly, yet it may be useful to emphasize certain points of view which come sharply to our attention when we attempt to survey the field.

WAR'S DAMAGE TO UNAPPLIED CHEMISTRY

We could scarcely expect to estimate the retarding effect of the war on chemistry, because we can not pry into it deeply and broadly enough to prove our impressions, for research is partly in the minds of scientific workers. However, certain signs of influences actually exist which tend to weaken and retard progress. The American Chemical Society of some 9,000 members, the largest chemical society in the world, publishes twice a month the journal *Chemical Abstracts*. Its editorial offices are in the chemistry building, a few steps from the one in which we are now assembled. *Chemical Abstracts* has for some years covered the field of chemistry by abstracts more thoroughly than any foreign journal of the kind. It reviews some 600 journals from all parts of the world and there is spent upon it by the American Chemical Society an annual budget of over $40,000. It is easily seen that this must be the most powerful and most important agency for research in chemistry, and perhaps also in any science, that exists in the world. Some quantitative idea of the evil effect of the war upon chemistry in general may be gotten from its effects upon this colossal agency for assisting applied as well as unapplied research in chemistry.

Inquiry to the editor of *Chemical Abstracts* developed that the effect of the war on current chemical literature as reflected in *Chemical Abstracts* may be shown approximately by the following statement:

Total No. of abstracts published (patents included) in 1913	25,971
Total No. of abstracts published (patents included) in 1914	24,388
Total No. of abstracts published (patents included) in 1915	18,449
Total No. of abstracts published (patents included) in 1916	15,784

These figures are fairly representative of actual publication of original papers of more or less direct interest to chemists, as *Chemical Abstracts* has continued closely to approach completeness in spite of war conditions. The quality of the papers being published is somewhat below the normal standard. Not a great many foreign chemical journals have entirely ceased publication since the war started, but all show a more or less marked decrease in the number of pages turned out. Most of the French and German journals are published much less frequently than in normal times, two or more numbers being grouped under one cover. Apparently no important English, Italian or Russian chemical journal has ceased publication since the war started. The following list includes the journals concerning which we have uncertain information but which *indicates* that they have probably ceased publication due to the war:

English:

Chemical World.

One journal.

German:

Böhmische Bierb.
Deut. med. Wochschr.
Leipziger Färber-Ztg.
Silikat-Z.
Technikum.
Zentr. Exp. Med.
Z. exp. Med.
Z. Hyg.

Eight journals.

French:

Ann. Mines.
Arch. biol.
Arch. intern. pharmacodyn.
Arch. intern. physiol.
Arch. med. exp.
Betterave.
Brass. malt.
Bull. sci. pharmacol.
Bull. soc. franc. min.
Bull. soc. geol. France.
Bull. soc. ind. Amiens.
Bull. soc. ind. min.
Bull. soc. ind. Mulhouse.
LeCuir.
L'Engrais.

J. d'agr. trop.
J. des. fabr. sucre.
J. physique.
J. sci. math. phys. nat.
Radium.
Mon. ceram. verr.
Mon. teint.
Nord Brass.
Papier.
Petit brasseur.
Rev. chim. appl.
Rev. chim. ind.
Rev. electrochim.
Rev. viticulture.
Rev. gen. mat. color.
Sucrerie Ind. colon.
Thirty-one journals.

Austrian:
Oesterr. Z. Berg. Hüttenw.
One journal.

Belgian:
Bull. acad. roy. med. belg.
Bull. sci. acad. roy. belg.
Bull. soc. chim. belg.
J. pharm. soc. d'anvers.
Rev. intern. pharm.
Sucrerie Belg.
Chimiste.
Seven journals.

The *cost of publication* of *Chemical Abstracts* has been increased by about 10 per cent. as a result of the war. This is chiefly due to the increased cost of paper. The same percentage increase will enter into the cost of the Decennial Index to *Chemical Abstracts,* which is about to be issued by the American Chemical Society at a cost of over $30,000.

Need we go further for evidence of the ill effects of war upon science? Certainly it takes little insight to see that this stoppage or at least side-tracking of the wheels of chemical research will be felt in this science for years to come.

WAR'S RELATION TO APPLIED CHEMISTRY

In considering the applied side of chemistry let us remember that war is essentially engineering. Its object is to overcome natural and artificial obstacles. It must therefore get results which are deliberately selected at the will of those directing the war. It insists, therefore, that every one and everything must produce. Its *main* agents are engineering and applied chemistry, the engineering, because it struggles with the problems of space and time and material for tools and weapons, and applied chemistry, because it is a necessary handmaiden to efficient engineering, and in addition furnishes the source and vehicle for convenient and effective handling of energy in the most concentrated forms. The chemical energy of the modern high explosive is the strong right arm of the fighting force and without it armies are but chaff. With British control of the seas, German armies with all their numbers, thorough equipment and splendid military power, would have been impotent in a few weeks or months without the chemical ability to get nitric acid from atmospheric nitrogen instead of Chilean nitrate, for without nitric acid high explosives and even smokeless powder are impossible.

The time at our disposal is too brief to touch on all the divisions of applied chemistry. Much progress, for instance, has been made in the domain of the special branch called engineering chemistry which involves among other things, the chemical investigation of materials for alloys, shrapnel, aeroplanes, submarines and other war supplies. It would be unwise, now that we have become involved in the war, to deal publicly with some of the improvements in this field, for they are vital as well as interesting. Some of us have followed the policy during the last three years of not even discussing with our colleagues or students such innovations of military importance in this and the allied countries as have come to our attention, which might by any means percolate into Germany. The branch of applied chemistry known as metallurgy in which this country is perhaps the most

highly developed in the world also renders distinct service in war time because it is vital to engineering and in the production of arms and ammunition. We, however, will emphasize more particularly the twin fields of industrial chemistry and chemical engineering, because in the nature of things this field is less popularly known even among chemists. Industrial chemistry is that branch of chemistry which uses all the rest of chemistry and much engineering, for the furtherance of production of chemical substances, or, the use of chemical means or methods for manufacturing any material of commerce. Chemical engineering is that branch of engineering and industrial chemistry which applies engineering principles and methods to chemical manufacturing or production. Because their aim is production these two fields have been largely dominated by war conditions for the past three years. On them the war has had two mutually antagonistic effects, the one retarding or injuring and the other developing and benefiting.

WAR'S DAMAGE TO CHEMICAL INDUSTRY

The main factors vital to success in any chemical industry are

I. Thorough knowledge of an assured market.

II. Possession of at least one well studied and workable chemical process and chemical ability to handle it economically under varying raw material and finished product markets.

III. Possession of engineering ability to carry out and maintain in operation the chemistry involved in the process.

IV. Sufficient margin of profit to attract capital and business confidence in chemical and engineering ability in meeting the problems of the field.

Any thing or any one who weakens or strikes at any of these four factors is an enemy of chemical industry and does damage to it.

When war was declared in Europe stagnation set in at once in the chemical industries and indications of disaster were the rule in many of them. Petroleum refining, turpentine, rosin and wood products among others, were hard hit because we are strong exporters and such industries as mixed fertilizer manufacture also, because we import heavily of potash. This stagnation could not last long since the chemical industries underlie the whole fabric of modern industrial development and civilization, and production is necessary to life. Eventually, therefore, the chemical industries were forced to resume operations but great uncertainty as to markets rendered operations difficult and held back many changes in processes and equipment rendered necessary by changes in source or kind of raw materials. The nature of these industries is often such that the failure of supply of one chemical raw material even if used in but limited amounts may prove fatal by rendering the product unsatisfactory to the market if indeed it is not entirely valueless. A good illustration of the vital importance of accurate knowledge of the market in these chemical industries is furnished by the dye situation, where we had recently the anomalous condition of bitter complaint of shortage by consumers simultaneously with utter inability of some producers to market their product, and still other producers with large contracts for product and inability to produce due to poor deliveries or failure of equipment. These difficulties do much harm since they tend to discourage capital and it must not be forgotten that industrial chemical development is impossible without capital. German chemical manufacturers understood this clearly when they organized American branches of their color works, eliminating American employees to conceal

the market and its peculiarities, and placing all their business in the hands of "American citizens" of German name. Then when the U. S. Bureau of Foreign and Domestic Commerce attempted last September to publish the amounts of each dye consumed in this country they vigorously protested that their rights as American citizens were being infringed by encouraging competition. The uncovering of this octopus to public gaze should be set down to the war's credit. It has long been a familiar animal to many industrial chemists.

Another evil effect of war, a common one now greatly intensified, is the discouragement of capital by failure of hasty and ill-advised manufacturing projects. Successful speculators and others have been influenced by the potential earning capacity of industrial chemistry and have jumped into projects with little study and no experience. Often such capital has not known enough to employ chemical engineers, but has put growing works into the hands of electrical and mechanical engineers whose general engineering sense has not always saved them from physical disasters that chemical experience would have avoided. Such engineers and capital and, sad to say, many chemists, who either lacking entirely in manufacturing experience or having *had* manufacturing experience, though they acquired no sense of responsibility to protect capital against hazard from decisions without basis in experience, have been the easy victims of the machinery and equipment company who needs but to see a plant, or a picture in a book, and they will design you one while you wait. There not being the proper engineering check such plants fail at times with regretable loss of life, as well as capital and confidence in things chemical, or if they succeed (because the process is simple and well known) the plant can be counted upon to cost from 50 to 100 or more per cent. higher than it should.

The equipment companies and their engineers are not necessarily dishonest. They sell equipment, and who but they are responsible if they do not sell you enough equipment when you consult them for advice in designing our plant? They, therefore, sell you enough. Experienced engineers will often cut the estimates of such equipment manufacturers in half.

Another illustration of how this situation works out in practise might be given in the case of benzol refining. This is an important matter in modern high explosive manufacture. Some little time ago the best text ever written in English on industrial chemistry contained a chapter by a chemical engineer who had ample opportunity of observing the best American practise (which happens to be second to none in the world). His chapter on this subject, therefore, is a classic, but in illustrating the text he did not reproduce details of stills, for instance, with engineering exactness, but allowed the artist who made the drawings considerable leeway to his imagination. In fact, he left out entirely a vital feature in the construction of such stills. Were it not for the loss of efficiency and the expense involved, you would be greatly amused if you could go with me to a number of the refineries built in this country in the last two years under war pressure by machinery companies, for good engineers who were not themselves experienced in this industry but who needed the industry as one of the links in their larger operations. In every case the stills were built exactly patterned after the pictures in this text and in no case were they efficient or as nearly efficient as was possible, if a little thought regarding the use to which they would be put had been given them. They were built to sell, not to operate.

The same capital newly invested in

chemistry is also the easy victim of another evil which is necessarily costly to industrial chemistry and is a heavy blow to the whole science. This evil is the ignorant or unscrupulous chemist. The great difference between industrial chemical research and other chemical research is that the former *must* produce results on the question in hand while the latter may ramble if necessary into less difficult fields. When inexperienced capital is seeking chemical assistance, the first individual it meets who claims to be a chemist is assumed to be competent to handle any problem without inquiry into his past experience. This same capital would scarcely employ a bridge engineer to design a dynamo, yet plant after plant for chemical manufacture has been constructed in the last two years in this country with no more intelligence than this. As a result literally millions have been squandered and lost in these unsuccessful plants. But unfortunately, enough such plants are successful, that their authors escape the penalty of their dishonesty, and therefore, the evil persists and continues. Plants have been constructed for the manufacture of high explosives by engineers who knew nothing of the business, resulting in great loss of property and even life from their final destruction, or in abandonment where they proved unprofitable. I have heard of plants erected for the concentration of sulphuric acid in which a battery of stills for this purpose costing in the neighborhood of a quarter of a million dollars was placed in operation without even a single experiment preliminary to erection, on the type of material to be used, and not even a trial run on *one* of the stills before all were placed in operation. The first day they operated was the last day, for they all went into solution in the acid.

Men who were or claimed to be chemists have read how simply some reactions described in the general chemistries work, and designed a plant upon their nerve or—as they thought—common sense, and found to their consternation that under the conditions they made for themselves the reaction did not proceed at all, or they were so inexperienced in large-scale operations that they could not recognize what they had when the work was under way. Others have so far lost their heads by publicity or financial possibilities, even though good chemists, that they have assumed that what could be done with raw material from one source could be equally well done with it when from another source, provided they merely proved its actual presence in the new product. Ignoring the whole history of chemical as well as industrial chemical development that the chemical environment profoundly affects chemical reaction, no adequate confirmatory studies were made before capital to the extent of hundreds of thousands of dollars has been induced to invest in such guesses, with disastrous results to capital and grave loss of confidence in chemical research. These things are in large part due to or at least the losses could only be so heavy under war pressure. Processes which gave every promise of success have been hurried into failure or near failure by undue publicity giving premature capitalistic confidence in them and it is with profound regret that we see the passing for the time at least of such things as toluol from petroleum, which more attention to study may still make useful in war emergency at least.

These are outlines of some of the evil influences due to or accentuated by war. They are in part of such a technical or professional nature that they should not have been imposed upon your attention unless it were to protect you against misunderstanding the just criticism of the results of these evils and to emphasize that we do not consider war an unmitigated blessing if we

should appear enthusiastic about the progress that has been made in war time. Then too we should always ponder more over our lapses. The successes can take care of themselves.

PROGRESS IN APPLIED CHEMISTRY IN WAR TIME

There is indeed another side than the evil we have been discussing. There has been much real progress. The evils mentioned are largely growing pains. Engineering and its services to mankind have been long appreciated to some extent at least. Chemistry is less easily understood. The everywhere present applications of chemistry pass unnoticed for the most part in everyday life. Probably the greatest contribution to science, therefore, of the present war, is the awakening of the average mind to the power and value to mankind of that group of phenomena which we study as chemistry. This is probably because we most easily grasp and appreciate applications rather than generalizations, and the use of chemistry in war has been a revelation to the general public.

In other ways also this war has effected a development in chemistry and its applications which has outstripped any influence since the modern foundations of the science were laid over a century ago. It will be many years before the influence will mature and become apparent or measurable. Nevertheless, we do not crave progress or development at such a price as war.

We must recognize, however, that severe disturbances are very effective in dislocating fetishes, for instance. So, one of the phases of this struggle which is noteworthy is the public awakening to consciousness of the power of chemistry and the universal distribution of the ability to use it promptly and effectively, as against the old idea, that this power and this ability is possessed by a chosen few. An illustration or two will perhaps show that this latter idea is still too prevalent.

I have met manufacturers since the war whose operations were brought to a full stop by lack of some raw material or other who complacently accepted their fate on the ground that they could not get a German chemist. They had no bias in favor of Germany at all. They just thought it was a matter of common information that chemists were domestic animals imported from the Black Forest. Would you believe that some of these manufacturers were engineers graduated from some of our large colleges of engineering and not men without education?

In such a time as this we see that our keeping quiet about the progress and development of American chemistry in years gone by, was criminal, for much harm results from lack of information as well as from misinformation. There are always patriotic Germans and others who praise their country's achievements to us and as I pointed out last year in SCIENCE, we are glad to see this and our university teachers of chemistry have been lavish in their praise, particularly of German chemistry. They, however, are not rendering very good service to the community when, as they should, they give such praise, if they fail to make a real effort to find out also, what is going on in their own country. We university professors feel abused if it is inferred that we are not well informed, yet we innocently assume as the only modern development in chemistry the latest tale of achievement from a German dye advertisement and these lads know how to use the educated public and university chemistry professors as well, in furthering their advertising propaganda. Much good work has been done by the *Journal of Industrial and Engineering Chemistry* in publishing a series of articles by authorities on what the American chemist has done for the in-

dividual industries. Time only will eradicate the evil. Only a short time ago I was at a banquet of a society of engineers in an eastern city. The professor of chemistry from a near-by university was an invited speaker. He was a revered and respected man among American chemists and a man of affairs, too, but he lived in the dark ages of chemical achievement. He spent half of his time telling how wonderful chemistry was and how great the achievements of foreign chemistry in particular and not one word of American chemistry. Yet in his own city in the last three years has sprung up a chemical industry that is marvelous, and which he did not know existed. In his own line, organic chemistry, was a plant for making certain organic materials used in war, by a series of steps that has no counterpart in chemical literature for the magnitude and conception of its chemical engineering operations. It is not only the largest scale upon which all of its many operations have ever been conducted, but its chemistry is a series of highly interesting adaptations and developments. When peace comes again, if that plant still prospers it will be a useful aid in the solution of one of our most important engineering problems of this generation. Americans are not wizards that they do in two years what it took German chemists decades to work into. Such things are only done where the ability exists and the power born of experience in solving similar chemical problems is possessed. It is not right to our students, you who teach, to praise the competitors of our compatriots and never stir ourselves to be informed on what our own countrymen are doing, even if the foreign achievements are served up to us, ready to teach, as paid advertisement of German dye-makers. The German general staff has learned, if others have not, that German chemical achievement which is great, indeed, is no sign that equal ability does not exist elsewhere. The allies and America improvised a munitions industry in two years to match their machine of forty years' preparation. Such an achievement is only the natural result of our present industrial chemical development in America and the allied countries. There is nothing in the rate of American industrial chemical development of which any American need be ashamed.

The progress in industrial chemistry and chemical engineering in the last three years itself, in this country has been wonderful. Let me protest, however, that this is no ground for the philosophy which I understand obtains in some quarters, that war is a desirable, natural, logical or sort of evolutionary benefit. All this progress is in spite of war. War could force us to do nothing we did not possess capacity for before. Because war changes the normal relations between supply and demand, cost and selling price, gives us opportunities to do only what we could do anyway, if the same demand arose from any other cause.

Industrial chemical tendencies during the war have been governed by unusual demands for chemicals from abroad in addition to war drains, healthy home requirements, new demands from industries formerly supplied from abroad or forced to use new raw material by scarcity or high prices, together with speculation, raising prices to unusual levels. This resulted in expansion of existing plants, rapid installation of new ones, hasty perfecting of new processes already slowly maturing and the seizing of opportunities to profit by high prices through erection of small plants for the production of special chemical materials and through the development of processes hitherto existing as possibilities, only, in the minds of chemists. This has greatly extended also the supplying of chemical construction materials and machinery and has increased the opportunities for the

rapid development of inventions in this line. The progress made here alone has been as great as has been accomplished in many individual decades in the past. The importance of this is apparent when we consider that if the chemical engineer had at his disposal as efficient apparatus and materials of construction in his plant, as exist in the chemical laboratories of the present day, or as the mechanical and electrical engineers have in their work, progress in the arts would be at least a hundred years ahead of its present development.

The tendency to manufacture at the market is another good development which has been greatly accentuated by the war. For some time there has been a growing tendency for manufacturers who are large consumers of chemicals to produce these chemicals themselves. Assisted by gradual price elevation, this tendency has been greatly encouraged by the invention in the last two decades of processes and machines of merit which could find no sale as such, in well-established chemical manufacturing plants, because they frequently offered insufficient advantages to warrant discarding those already operating, or were merely alternative in their character. A good example of how this tendency to manufacture at the market works out normally where the impelling force is merely gradually advancing prices, competition preventing excessive elevation, is to be seen among others in the case of bleach for paper manufacturing. Consumers of alkali and bleach, such as progressive paper manufacturers, operating on a large scale, and others have experimented for years with inventions for the electrolytic production of these materials from common salt. Our present high development in this branch of chemical industry is in no small degree due to these individual efforts, many of which during the past twenty years have been eminently successful. High prices and poor deliveries in the last two years have forced matters to a head in this direction. Where formerly we had a few large chemical plants manufacturing caustic soda and chlorine for bleach by electro-chemical means, we now have distributed throughout the country a great number of concerns who have added to their equipment a plant for the production of these products. The operation of these units under widely diverse conditions will greatly enrich our chemical engineering experience. A number of cell types are obtainable which operate economically. Some of these are well advertised in the current literature, but some, though equally successful, such as the Allen-Moore, Gibbs and Nelson cells are not so well known. The cell portion of such a plant is only a fraction, however, of the equipment required and it is important that the rest of the plant should be properly designed. The simpler and more durable, therefore, the design of apparatus, the more satisfactory the entire equipment will be. There has been placed in operation in some eight plants recently a total of nearly 2,000 cells of one type alone, with a daily capacity of 200,000 pounds of chlorine gas. Some plants constructed this year cost as much as a half million dollars. These will be valuable for defense, for we use much chlorine in making guncotton or nitro-cellulose, for mines and smokeless powder.

This use of alternative inventions is valuable in encouraging new invention and much industrial chemical investigation, and alleviates to some extent the ill effects of unwarranted increase in selling prices.

Progress in Chemical Engineering may be illustrated perhaps best by the progress in acid-making equipment. High pressure manufacturing of chemicals and difficulty of obtaining supplies has brought rapid improvements and development of chemical engineering materials by compelling large

scale experimentation on new products and substitutes. To resist corrosion by acid and other chemicals, pottery or so-called chemical stoneware, glass and natural stone apparatus have been used heretofore. This necessitated small-sized apparatus, and meant in the case of stoneware a manufacturing time of about two months for the clay working, drying and cooling after firing. Attempts have been made for many years to replace this material by metal. Platinum, silver and gold are used in special cases, but while these metals can be made into any size apparatus, cost is prohibitive for most uses. Two classes of alloys have now been developed: rare metal alloys such as tungsten, chromium, or nickel irons, and more recently the cheaper and more resistant silicon-iron alloys. Extensive trials in the last two years have shown the usefulness of these alloys though they do not possess quite the resistance of stoneware to corrosion. They are known under varying trade names, such as durion, made here in Ohio, tantiron and ironac. They are very resistant to all strengths of sulphuric and nitric acids and are used with great satisfaction in their manufacture and permit plants to run for months without shut-down. The success of the modern tower system displacing platinum for concentrating sulphuric acid had been largely due to the use of pipes and fittings of this alloy. Early in 1915 the demand for nitric acid for war purposes increased to enormous proportions, resulting in extensions to old nitric acid plants and the erection of new ones larger than the world had ever seen. Deliveries on stoneware jumped to six months and even longer and had the production of nitric acid been dependent upon stoneware alone, as a few years ago, it would have been greatly curtailed and the story of the great war would have been different. As these alloys can be secured on short notice, the same as cast iron, chemical manufacturers do not hesitate, if a still should run wild and froth sodium sulphate into the condenser, to direct workmen to break the connections at once with a hammer and allow the expelled material to flow on the floor, thus preventing the wrecking of the condensing apparatus. New castings can replace the broken one at once. Such extravagant handling of the material would not be possible under the usual slow deliveries with stoneware. This freedom from risk of damage to condensers, and the making of condensers themselves of this material, enables stills to carry a heavier charge and operate at greater speed. Where the old equipment charged 2,000 pounds once or twice in 24 hours these wartime stills operate on 4,000 pounds of nitre plus 4,000 pounds of sulphuric acid, charging three times per 24 hours. The alloy is somewhat brittle, but very much less so than chemical stoneware. It is easy to see these silicon-iron alloys are a boon to the acid industries and thousands of tons of casting are in use and new chemical processes are possible and now in operation, too, which could not exist before, because of lack of suitable material of which to construct apparatus. Some of these new processes are having a decided value in the Allies' campaigns. No single development in many decades has had as much influence as this one has and will have, for it is only in its infancy.

I need not weary you with other illustrations of progress, though much has been accomplished in many lines and radically new chemical processes developed. The most wonderful and greatest chemical works I have ever seen have been erected in this country since the war began and the best of them were coal-tar dye and synthetic organic chemical works. Reasonable progress has been made in American laboratory glass and porcelain. After the war we are

going to be independent of importation in gross coal-tar products and practically, if not entirely, in ammonia for fertilizers. We are also weeding out the unnecessary use of potash where it replaces soda due to our own careless teaching of chemistry in speaking of and using potassium compounds where sodium serves as well. German potash exporters and others, such as for Saxony manganese, after the war will have an expensive campaign to win us back to these former unwarranted uses of their product.

The relation of chemistry to national defense has been rendered clear by the war, a service of no mean magnitude.

Explosives and asphyxiating gas manufacture are dependent upon labyrinthian chemical engineering operations. It is obviously necessary for adequate preparedness that this country should be self-contained and not dependent upon importation for such supplies as nitric acid, toluol and sulphuric acid for defense. We have the sulphur and pyrites for sulphuric acid. The toluol and other coal-tar products we have ample for our usual needs, but in time of war toloul becomes the basis of "T. N. T." or trinitrotoluol, one of the most effective high-power military explosives. The erection of new coke oven plants has but partially met the demand for toluol in the last two years. In defending ourselves this would be too slow, for such installations are difficult to get under successful operation in less than a year. A large and well-established dye industry, therefore, is vital for defense, for it would produce a bigger demand for coal-tar products and toluol production in peace times and its operations are quickly convertible into ones for producing high explosives. It is to be hoped, therefore, that the German alliance with our textile manufacturers may be broken up during this war so that Congress will be less helpless in fostering this dye industry as a matter of defense than it has been in the past. The expense of storing within the country nitrate of soda imported from Chili, adequate for the nitric acid of munitions production in case of war, would tie up millions. The government will establish a plant to make nitric acid from the atmosphere. The Norwegian process (electric arc) is stated to require five times as much power, a vital factor, as is required in the making of nitric acid from cyanamide. Germany has installed, for making cyanamide, during the war, additional equipment costing $100,000,000, utilizing over 60,000 horse-power and producing about 200,000 tons per year of nitric acid, requiring the most feverish activity for a year and a half on the part of her chemical engineers. We have some American suggestions which if successful will take less power than the German method. Any method for nitric acid producing ammonia also, is desirable as an aid to agriculture. Prices asked for power are much higher than abroad, and as the cost of the engineering is only about 10 per cent. of the total charges in electric power installation, it becomes evident that efficient national defense and economic agriculture depend on more economic banking methods. So in every instance we are confronted with the problems of peace when working out national defense. It should be remembered that our usual source of nitrogen derivatives, the ammonia of by-product coke, brings with it the indispensable toluol, and no electrical method does this. Before the government nitrogen plant is built, therefore, it should be a matter of serious inquiry whether the government's $20,000,000 might not bring the same result and give a liberal supply of toluol besides, if invested in by-product coke expansion, for much of our coke is still made without saving by-products.

It is an open secret that the acceptance of

war orders in this country strained to the breaking point our best organized chemical industries. The mere request by the allied countries two years ago for our soda, benzol, toluol and our explosives for only a *small portion* of their demands, produced a state of affairs in our industries that was an appalling warning against the time when we would need such things ourselves, for defense, and in immensely greater volume.

It is natural, in view of the nature of these defense problems, that the engineers and chemists of the country have been serious in the preparedness movement. Thirty thousand engineers and chemists of the United States volunteered without pay to the National Consulting Board for both the navy and army to work on the organization of the industries of the country for national defense. The result was much more efficient than any similar organization carried out in the world, for no government could afford to pay for the expert services involved. This consulting board and its successor the National Council for Defense, have assisted the country to become self-contained for defense, arranged for speedy conversion of industrial plants into munitions plants and arranged during peace to prevent useless waste of experienced engineers. Experienced chemical engineers, for instance, like naval officers, can not be trained in a day or a year, though the analytical chemical control can be taught in a few days to any chemist. The mistakes made by Britain in passing through the blockade materials helpful in explosive manufacture demands that our military authority and foreign office have at its call as wide a variety of chemical experience and advice as possible, and every chemist as well as engineer in this country is now being card indexed.

If we, as scientists, ask ourselves individually what we can do to assist in the general defense of our firesides and our ideals, the answer is do our daily work in whatever field it may be, as though it were the most important single thing in the world and *particularly do our utmost to assist production and those directly engaged in it, whether manufacturing or agricultural.* Then when the government calls upon us for special service we will be ready to attack the problems which only the military arm can formulate for us.

We have touched on sufficient high points to indicate the character of the influence of the war upon chemistry in America. Still other points should be discussed, were there time. Hardly any branch of the science but contributes an important service to the national defense as well as our normal benefit.

After all, is not chemistry and science itself a pretty matter in the presence of this world calamity and the personal suffering ever upon our minds? Have we not often wondered what we had done to be spared to this minute, from such things? It may be proper to say we do not quarrel with the German people as such, but with the ideals and acts of their leaders and government. Do not let that point of view toward our neighbor, however, be used by us to excuse our individual responsibility for this government and its every act. We are responsible, and we alone. We have seen conclusive proof in the last three years that science and education are merely aids and not specifics against international immortality and that the devotees of science are as easily misled as others when the leaders too are scientific. Though this war has long become evident as a war for privilege and the exploitation of the weak by the strong, and the doctrine that the state *can* do no wrong rather than that the state *must* do no wrong, let us not deceive ourselves that our abolition of aristocratic government is a specific for this malady, for it is not. This is our constant battle still, even under our form of government.

It has become so evident in this war that the intelligent and scientific criminal is a terrible menace, and dislodging him at times such a weary and fatal task, that we must find some way of preventing our leaders and groups or classes, whether governmental or industrial, from becoming this kind of danger.

Have we not reached the time when we are willing to turn to the One who ordained civil government for our good, acknowledge that He ordained it and not we ourselves, and make our leaders or rulers "whom God and this people shall choose"—"men fearing God and hating covetousness"?

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Industrial Chemistry Laboratory,
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SCIENTIFIC EVENTS

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION

According to the annual report of the trustees of the American Medical Association the principal expense in the publication of *The Journal* is that of paper, this expense being one third of the total expenses. The price of paper began to go up rapidly in the spring of last year. About June and July, book paper was almost unobtainable and commanded a price three or four times what was being paid, the low rate prevailing for the entire year 1915, the cost of paper being approximately $116,000. In 1916 the cost of paper was approximately $134,000—an increase of about $18,000 over the preceding year. It is estimated that for the present year, 1917, the paper will cost about $170,000. This means an increase in 1917 over last year of $37,000, and of $54,000 over 1915.

These new conditions presented problems to the board that had to be met. It was necessary to increase the annual subscription price, decrease the size of *The Journal,* or get along with decreased income. Increasing the subscription price was not possible. But the size of *The Journal,* it is said, can be reduced without seriously lessening its value or its usefulness to its readers. The number of fellows of the association receiving *The Journal* has been as follows:

1900	8,445
1901	9,841
1902	11,107
1903	12,553
1904	13,899
1905	17,570
1906	20,826
1907	26,255
1908	29,382
1909	31,999
1910	33,032
1911	33,540
1912	33,250
1913	36,082
1914	39,518
1915	41,254
1916	41,938
1917	42,744

The above figures do not include honorary fellows, nor those fellows who have substituted *The Archives* or the *Children's Journal* for *The Journal* of the American Medical Association.

APPROPRIATIONS FOR CORNELL UNIVERSITY

Governor Whitman, of New York state, has signed the annual appropriation bill which provides for the expenses of the two state colleges at Cornell University during the coming fiscal year, from July 1, 1917, to June 30, 1918.

We learn from the Cornell *Alumni Weekly* that the bill carries for the State College of Agriculture $779,401. Of this amount $35,750 is to provide for specific deficiencies in appropriations made by the two preceding legislatures. The present legislature had already passed, some six weeks ago, an emergency item of $55,910 for the College of Agriculture to enable it to carry on its work during the current year in view of the reduction in the general appropriation bill a year ago. When this emergency item is added to the general appropriation bill just passed it makes a gross appropriation provided by the present legislature of $835,311 as against a gross appropriation of $518,325.66 made by the 1916 legislature, or an increase of $316,985.34. When, however, the

emergency and deficiency items, which together amount to $91,660, are subtracted, there is left a net appropriation of $743,651 for the year 1917–18.

In addition to the above appropriations the general appropriation bill this year provides a specific item of $42,000 for printing the publications of the College of Agriculture. Heretofore no special appropriation for printing has been made, but the college printing has been paid for out of a lump appropriation known as the legislative printing fund. The printing for the next fiscal year must be limited to the amount of this specific item.

Included in the $743,651 in the general appropriation bill are a number of small items, of which the aggregate sum is $34,000, for new construction and improvements. The largest of these is an appropriation of $12,000 for the addition of a unit to the central heating plant. When this unit is installed the old heating plant in Roberts Hall is to be removed and the boiler room remodeled to provide additional space for the general purposes of the college. An item of $8,000 is included for remodeling this boiler room. To put in additional roads, sidewalks and drains and general improvements to the grounds, $5,000 is provided; for a new piggery with detached pens, $7,000; for a packing shed on the pomology grounds, $1,000, and for small storage houses for the department of plant breeding a small item is included.

AN INSTITUTE OF APPLIED OPTICS FOR FRANCE

MR. E. S. HODGSON writes in *Nature* that a scheme is on foot in Paris to establish an Institute of Applied Optics, with the object of securing closer cooperation between theory and practise in the optical trade. It has been suggested, according to an article in *La Nature*, that the scope of the institute should fall into three sections, viz., (i) a college of optics, providing a thorough theoretical and practical training for opticians, and promoting among its students a taste for optical research; (ii) a central optical laboratory, where tests of glasses and optical instruments would be made for men of science, public bodies and manufacturers and research work of general interest carried out; and (iii) a special trade school in which the students could obtain a thorough training in the practical branches of the trade.

It is proposed that the institute should publish transactions in a form following, the *Zeitschrift für Instrumentenkunde*. The students of the college of optics would be recruited from the educated classes—army and navy officers, students or ex-students of the universities and technical colleges, astronomers, illuminating engineers, manufacturers of optical instruments and doctors interested in physiological optics. There would be two distinct branches of instruction, viz., general optics and instrumental optics. The courses would be supplemented by lectures on all modern optical questions. The period of study is suggested as one year.

The central laboratory would serve as a test laboratory for manufacturers of optical instruments and for glass manufacturers, as a practise laboratory for the students, and as a research laboratory for the college staff.

The professional, or trade, school would take young people for three years and give them a thorough training in (i) glass-working, and (ii) construction and fitting up of optical instruments. The scheme has received the favorable consideration of various government departments and of certain scientific and learned societies in Paris; indeed, the publication of the transactions of the institute is already assured. While it would be difficult to install the machinery and plant necessary for the trade section of the institute, it is suggested that the program of the courses should be considered and the principal courses commenced in the school year of 1917–18.

THE CROCKER LAND EXPEDITION

DR. HARRISON J. HUNT, a member of the Crocker Land expedition, arrived in Copenhagen on June 2, reporting the expedition still in northern Greenland. Direct news from Donald B. MacMillan, head of the expedition, announcing that he and his companions had only enough supplies to last them until August of this year, has now been received by Dr. Henry Fairfield Osborn, presi-

dent of the American Museum of Natural History. Mr. MacMillan reports that both the relief vessels sent to his aid, the *George B. Cluett* and the *Danmark,* have failed to reach him and urges that a third be sent, as otherwise the party will be obliged to adopt Eskimo methods and live on the country.

George H. Sherwood, acting chairman of the Crocker Land Committee, composed of representatives of the American Museum of Natural History, the American Geographical Society and the University of Ilinois, announces that the steam sealer *Neptune* will be sent with all possible dispatch. This third effort to reach the party in the frozen north will cost at least $40,000, provided that the *Neptune* is able to reach the base at Etah, Greenland, and return by September next. The Committee hopes that in view of the extraordinary expenses it will receive substantial financial aid from the public. From the scientific point of view, the results of the expedition fully justify the heavy cost, it is said, although Crocker Land, which Rear-Admiral Peary thought he saw, has proved a land of mirage. Among other things, the party has discovered six new islands and mapped and explored Finlay Island, seen more than sixty years ago by Sir John Franklin, and yet never, so far as is known, actually visited by man.

The Crocker Land Expedition went north in 1913. Doctor Hovey, as chairman of the committee-in-charge of the expedition, left New York in 1915 to carry aid to Mr. MacMillan. He was in charge of the steamer *George B. Cluett,* which was chartered from the Grenfell Association. The *Cluett* reached North Star Bay in September, 1915, but, owing to the formation of ice, could not proceed further north. In this emergency Doctor Hovey proceeded a hundred and fifty miles to the headquarters of the expedition at Etah. Three members of the Crocker Land Expedition managed to reach Holstenberg in south Greenland and from there took ship for Copenhagen. Dr. Hovey remained with the Crocker Land party. In response to an appeal from him, the committee chartered the steamer *Danmark* from the Greenland Mining Company and dispatched her north to the relief of the party. The *Danmark* was reported on August 20 last buffeting the ice in Melville Bay.

SCIENTIFIC NOTES AND NEWS

Dr. Arthur Dean Bevan, of Chicago, was elected president of the American Medical Association at the meeting held in New York City last week. The meeting of the association next year will be at Chicago.

In honor of Dr. J. J. Stevenson, emeritus professor of geology in New York University, the faculty club house will be known as Stevenson Hall. One of the residences on the campus has been converted into a faculty club house, the equipping of the building for that purpose being done by the class of 1902.

Professor James F. Kemp, since 1891 professor of geology in Columbia University, has retired from active service owing to the impairment of his health.

Base Hospital No. 5, the Harvard Medical School unit, is reported as having arrived in Paris. Major Robert U. Patterson is in command of this unit, of which Dr. Harvey Cushing is director. Professor W. B. Cannon accompanies the unit to make investigations on the cause and treatment of "shock." Mr. McKeen Cattell is assisting him.

Dr. Livingston Farrand, president of the University of Colorado, will shortly go to France under the auspices of the Rockefeller Foundation to undertake work for the control of tuberculosis.

Columbia University has conferred its doctorate of science on Dr. George E. Hale, director of the Mount Wilson Solar Observatory, on Dr. Robert A. Millikan, professor of physics in the University of Chicago, and on Mr. Guglielmo Marconi.

New York University has conferred the degree of doctor of laws on Dr. Charles S. MacDonald, the alienist, and on Mr. Theodore N. Vail, president of the American Telegraph and Telephone Company.

Dr. Raymond Dodge, professor of psychology at Wesleyan University, has been appointed to

the Ernest Kempton Adams research fellowship at Columbia University.

DR. M. C. MERRILL, who has done graduate work at Cornell, Chicago, Harvard and Washington universities, and who has been director of the department of agriculture of the Idaho Technical Institute for the past two years, has been appointed horticulturist at the Utah Agricultural College. He will take up his work at Logan on July 1.

DR. ISADORE DYER, of Tulane University, has received an appointment as major in the Medical Officers' Reserve Corps.

DR. EDWARD R. BALDWIN, director of the Saranac Lake Laboratory, delivered the annual address before the Alpha Omega Alpha Honorary Medical Fraternity at Western Reserve Medical School on May 14. The subject was "Latent tuberculosis, its importance in military preparation."

ARNOLD LOCKWOOD FLETCHER, research assistant in geology at Trinity College, Dublin, has been killed in the war.

DR. FELIX LE DANTEC, professor of tropical pathology in the University of Bordeaux, died on June 7.

ACCORDING to *Nature* progress has been made with the proposal to establish a national memorial to the late Captain F. C. Selous, killed in action while leading his men in an attack on a German post in East Africa early in January last. An influential and representative committee has been formed under the chairmanship of the Rt. Hon. E. E. Montagu, M.P., with Mr. E. North Buxton and the Hon. W. P. Schreiner, C.M.G., as vice-chairmen. Among others who have joined the committee are Viscount Buxton, G.C.M.G., the Earl of Coventry, Dr. David (headmaster of Rugby), Lord Desborough, Viscount Grey, Colonel T. Roosevelt, Lieutenant-General J. C. Smuts, and representatives of the Royal Geographical Society, the Zoological Society, the Entomological Society, the British Ornithologists' Union, the Royal Colonial Institute and the British South Africa Company. The committee has decided, with the permission of the trustees of the British Museum, to place a mural tablet in the Natural History Museum, where many of Selous's finest trophies are exhibited. There is a general desire that some additional form of perpetuating his memory should be established. It is therefore proposed to found a Selous scholarship at Rugby (his old school), for the sons of officers, primarily of those who have fallen in the war.

THE *Journal* of the American Medical Association states that Major Hugh-Hampton Young, M. R. C., Baltimore, director of the James Buchanan Brady Institute at the Johns Hopkins Hospital, has been selected to head the special mission under the direction of General William C. Gorgas, Washington, D. C., and the Council of National Defense that is to study medical necessities at the battle front, and will have entire charge of the medical care of the American Army in France. Dr. Young has already started on his mission and on his arrival in England will report to Surgeon-General Sir Alfred Keogh. He and his staff will also report on the advisability of establishing in this country a hospital for the care of wounded and disabled American soldiers who may have to be sent home. Dr. Young will be accompanied by Captain Louis C. Lehr, of Georgetown University, Captain Montague L. Boyd, of Emery College, Atlanta, and Lieutenant Howard L. Cecil, of the Brady Institute, Johns Hopkins Hospital.

THE *British Medical Journal* states that Mr. Alfred T. Davies, of the Board of Education, has written under the title "Student Captives" a short account of the British prisoners of war book scheme (educational), whose object is to provide British prisoners of war interned in enemy or neutral countries with educational books. His pamphlet shows how much trouble has been taken by the committee to provide the prisoners with mental interests, and to make suitable provision for their education so as to enable them to redeem the time of their captivity. It includes letters of approval from Lord Crewe and the president of the Board of Education. Letters of inquiry should be addressed to A. T. Davies, Esq., C.B., Board of Educa-

tion, Whitehall, London, S.W.L., and the words "Prisoners of War" written in the left-hand top corner.

The Eugenics Research Association will hold its next annual meeting on June 22 and 23, in conjunction with the annual conference of field workers of the Eugenics Record Office. The sessions of Friday will be held at Cold Spring Harbor and that of Saturday morning at the rooms of the Brooklyn Institute of Arts and Sciences.

A new volume, the seventh, of the exhaustive report on the extensive and valuable phosphate deposits of the Russian Empire, was issued last year. This gives the results of investigations carried on during 1914; since the outbreak of the war the activity in this field has, of course, been almost exclusively productive. A general résumé of the results is given in Russian by the editor, Professor J. Samojloff, in a short prefatory section of 25 pages. This is succeeded by the special reports (in Russian) concerning the following localities: the Sisola and Lusa rivers in the Ustsysolsk district, government of Vologda, by V. G. Chimenkoff (pp. 1–32); the Aktjubinsk district by D. N. Sokoloff (pp. 33–60); the Dmitrovsk district, government of Orloff, by G. S. Burenin (pp. 61–124); the basin of the upper Kama in the Slobodsk district, government of Vjatka, by V. G. Chimenkoff (pp. 125–208); the Roslavl district, government of Smolensk, by A. P. Ivanoff (pp. 209–244); the region of the middle course of the river Zna, government of Tamboff, by A. S. Dobroff (pp. 245–312); the Pavlograd district, government of Ekaterinoslav, and the Isum district, government of Charkoff, by G. F. Mirtchink (pp. 313–327); the environs of Lake Indersk, Lbitchensk district, government of Uralsk, by A. N. Zamatin (pp. 327–332); the north part of the Temir district, government of Uralsk, by A. N. Zamatin and P. M. Vasiljeuskij (pp. 333–372); the northwest part of the government of Kursk, by A. N. and B. N. Semichatoff (pp. 373–456); the region of the lower course of the river Amudarja, by A. D. Archangelskij and B. N. Semichatoff (pp. 457–518); the Mosalsk, Metchovsk and Jisdra districts, government of Kaluga, by A. P. Ivanoff (pp. 519–546). The book concludes with "Contributions to the Mineralogy of Phosphates," by J. V. Samojloff.

The heirs of the late R. J. Lechmere Guppy, of the island of Trinidad, who died August 5, 1916, are offering for sale his large collection of shells and his extensive library, gathered during a period of more than fifty years' residence in Trinidad. A detailed manuscript catalogue has been submitted to the Smithsonian Institution with the request that it be open to inspection.

EDUCATIONAL NOTES AND NEWS

On June 2, Governor Ferguson vetoed the entire biannual appropriation for the maintenance of the main University of Texas at Austin and the medical department at Galveston. The amount involved is about two millions. The governor took this action after he had failed to force the board of regents to dismiss without proper cause the president of the university and several other members of the faculty. Unless some other means of support can be found, this action will force the University of Texas to close its doors for the next two years.

A chair of legislation in the law school of Columbia University has been endowed with the sum of $150,000 by Mr. Joseph P. Chamberlain. Dr. Thomas I. Perkinson has been appointed the first incumbent of the chair.

The sum of a hundred thousand dollars has been bequeathed to the University College of South Wales by the will of the late Dr. William Price.

Colonel Samuel E. Gilman, a member of the faculty of the West Point Military Academy, has been appointed superintendent to succeed Colonel Biddle, who has been assigned to the command of the Sixth Regiment of Engineers for service in France.

Professor William Chandler Bagley, Ph.D., director of the school of education of the University of Illinois, has been appointed professor of education in Teachers College, Columbia University.

GEORGES VAN BIESBRECK, of the Royal Observatory of Belgium, has been appointed assistant professor of practical astronomy at the University of Chicago.

PROFESSOR H. L. WHITE, formerly connected with the North Dakota Agricultural College, who is spending the present year in graduate work at the University of Wisconsin, has been elected professor of biological chemistry in the college of physicians and surgeons, medical department of the University of Southern California at Los Angeles.

ASSOCIATE PROFESSOR WILLIAM DRAPER HARKINS has been promoted to an assistant professorship of chemistry in the University of Chicago.

IN the department of anatomy of the college of physicians and surgeons, Columbia University, Dr. Oliver S. Strong and Dr. Vera Danchakoff, have been appointed to be assistant professors.

DR. HARRY CLARK, instructor in physics at Harvard University, has been appointed professor of physics at Victoria College, Wellington, New Zealand.

DISCUSSION AND CORRESPONDENCE

THE CENTRAL ILLINOIS TORNADO OF MAY 26, 1917

A TORNADO crossed Central Illinois from Pike County on the western side of the state almost directly east into Vigo County, Indiana, then bent southeastward into Monroe County, Indiana, on the afternoon of May 26, 1917. The tornado was responsible for the deaths of over 100 people, a large quantity of live stock, and the destruction of farm buildings and other improvements, railroad cars, and portions of a number of towns.

The greatest destruction was wrought in Coles County, Illinois, where it struck the residential districts of the workmen of the cities of Mattoon and Charleston—the former a city of 15,000, and the latter a city of 6,000. The tornado passed through this county between three and four P.M., *i. e.*, that part of the day in which tornadoes are generally most effective. Sixty people were killed, 500 homes demolished, and others seriously damaged in Mattoon at 3:30 P.M. Travelling at about 45 miles per hour the storm struck Charleston, 11 miles east of Mattoon at 3:45. Here, 34 were killed, over 400 homes more or less demolished, 15 industrial establishments partially or wholly destroyed, and two railway stations wiped out.

The track of the storm is about 225 miles long, but the length of the path in which almost complete devastation was wrought is about 40 miles. The width of the storm track varies from one fourth to one half mile, with an average of about one third of a mile. In numerous places minor damages resulted over an area about three fourths of a mile wide to the south of the track. The storm's path indicates that the tornado swerved slightly in some places and in others raised to the extent that serious effects did not result.

Destruction was most complete, in fact entirely complete in a zone from 500 to 700 feet wide to the right of the storm center's track. The parts of the two cities that were in this part of the storm track, with the exception of the heavier industrial buildings of Charleston, were more completely demolished than if a gigantic roller had passed over them, for the buildings were broken into short sticks, split into narrow pieces, and some parts carried rods and even miles eastward. Inspection shows three zones of variable destruction: First, the one of complete devastation; second, a zone from 300 to 500 feet wide to the left of the storm center's track and a similar one of similar width to the right of the devastated zone, where buildings are demolished beyond repair but not razed; and third, a zone still further to the right of the center where damages decrease outward from buildings moved to lifted roofs, fallen chimneys, and broken windows. Objects to the right of the center were moved forward and in, while objects to the left of the center were moved backward and in. Trees which were probably near the center were felled either north or south.

The reason for the location of the area of

complete devastation being to the right of the center seems to be plausibly explained when the agents of destruction are considered. On the right of the center there is the explosive action due to the reduced pressure on the outside of the buildings, the eastward component of the counter-clockwise wind of the tornado (probably over 400 miles per hour), the forward movement of the storm, and the west wind which was prevalent at that time all working in conjunction as agents of destruction; while on the left side of the center the westward component of the counter-clockwise wind is partially counterbalanced by the forward movement of the storm and the prevalent west wind. However, the backward or east wind of the storm was strong enough to move an eight room, one story house 41 feet to the westward, others shorter distances, to break elm trees 18 inches in diameter and to tip over a large percentage of the monuments in a cemetery in Mattoon.

Evidence of the explosive action so frequently stated as the principal agent in tornado destruction is not as general as one would expect. The north ends and the east roofs were pulled from some houses in the partially demolished districts; plate glass windows were broken and had fallen out; in one of the churches and a store in which the glass was supported by metallic strips the windows were made convex; a pump and 14 feet of water was sucked from a well; these, and the various forms of roofing which were picked off like feathers from a fowl, indicate the suction action of the storm. Although examples of explosion are not common, it is quite probable that in and near the center of the storm explosion was a big factor in the preparation of buildings for the crushing action of the wind.

Blunt cedar sticks were found imbedded one and one half inches in posts, and oatstraws one half inch in a maple tree. Another tree was decorated like an Indian's helmet with feathers. Huge oak and elm trees were twisted off, freight cars filled with brick were upset, as were also the tank cars of the Standard Oil Company. These and the buildings moved and crushed indicate the force of the wind of the storm.

METEROLOGICAL CONDITIONS

The *Daily Weather Map,* published at St. Louis at seven A.M. of the date of the storm, shows a well-defined cyclonic area covering most of the interior lowland of the United States. The isobars are oval in shape with their longest axis extending north and south. The isobars also show a slight bulging to the south in the southern quadrant. Cloudiness was prevalent over most of the Mississippi valley.

At 11 A.M.[1] a thunder shower occurred at Charleston. The clouds broke for a short time but lights were necessary at 2 P.M., and the air was exceedingly sultry and oppressive. At 3 P.M. a heavy, black, nimbus cloud appeared in the northwest, and frequent and fierce flashes of lightning occurred. Shortly before 3:45 a greenish black cumulo-nimbus cloud began to tumble in from the west. The wind suddenly changed from east to west through the south and hail began to fall. Then the hail lessened in amount and the wind attained a velocity of eighty miles per hour, the barometer dropped three tenths of an inch but came up immediately, and the temperature fell fourteen degrees. (Shown by the barograph and thermograph records.) Suddenly the wind lulled and flattened spheroidal hail, some having a major axis of 2¼ inches, fell until the ground was covered. The hail was accompanied and followed by a deluge of rain.

Although the funnel or balloon-shaped cloud of the tornado was not visible to those in the cities, it was seen and well described by numerous individuals who were west of the cities and to the right or left of the storm.

J. P. Carey

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June 4, 1917

[1] Observations made at the State Normal School, Charleston, one mile to the south of the storm track.

SCIENTIFIC BOOKS

Theoretical Chemistry. By WALTER NERNST. Trans. from revised seventh German edition by H. T. TIZARD. New York: The Macmillan Company, 1916. 22 × 15 cm.; pp. xix + 853. Price, $5.00.

This is a translation of the seventh German edition and as such is welcome. It would have been more welcome, however, if the publisher and the translator had been courageous enough and enterprising enough to have issued the volume some years ago. As it is, everything in the book is at least five years old and, in addition, the translator says: "The character of the work is slowly changing, since it is no longer possible in a book of this size to describe fully all the modern developments of theoretical chemistry. The new matter in this edition is therefore concerned mainly with Nernst's own researches. For example, there is a very interesting and clear account of the modern theory of solids, but, on the other hand, practically no mention of the recent advances in radio-activity and the atomic theory. These inevitable restrictions will hardly detract from the value of the book."

This is certainly a very tactful way of saying that Nernst is not willing to take the trouble to revise any parts of the book except those dealing with his own researches. In spite of the impossibility of describing fully the modern developments the translator has induced Professor Tutton to bring up to date all sections in the book dealing with crystallography.

In looking over a book like this, one is struck with passages which would have escaped notice three years ago. On p. 156 Nernst deduces that the osmotic pressure of a substance in mixed solvents follows the gas laws. He states that the resulting formula was verified satisfactorily by Roloff and then points out that the addition of potassium chloride to aqueous acetic acid may raise the partial pressure of the acetic acid. Most of us believe in some things which we know are not so; but it takes a special type of mind to claim that we have proved a thing in the same breath that we mention facts which disprove it. The case is not so striking on p. 707 where Nernst formulates the generalization that if two phases are in equilibrium with a third phase at a certain temperature with respect to a certain definite reaction, they are then in equilibrium with each other at the same temperature and with respect to the same temperature. This differs from the preceding case because no data are given to show the inaccuracy of the theorem. Nernst knows as well as anybody that an aqueous solution saturated with respect to sodium chloride is not in equilibrium with an alcoholic solution saturated with respect to sodium chloride at the same temperature; but the glamour of the phrase is upon him and he does not analyze it to see that what he has said is not the same as that two things which are equal to the same thing are equal to each other, though it may sound like that. This curious mixture of keenness and self-delusion is no longer an isolated phenomenon. We now know that it is a national weakness.

On p. 570 Nernst is quite willing to state that methyl orange is a basic indicator and that the acid function of methyl orange is unimportant as regards change of color; but he will not mention the fact that Ostwald holds an entirely different view. The people who read Ostwald's books also never learn that anybody questions the opposite view. It would be incompatible with the dignity of either to admit that he was wrong. Consequently the student who reads one set of text-books learns one group of facts as unquestioned, while he who reads another set of text-books learns another group of facts without any suspicion that these things are not accepted universally. Incidentally, it might be mentioned that Kahlenberg's name does not appear anywhere in the book and that there is no reference anywhere to any of the objections raised by Kahlenberg.

While one may object seriously to the order in which the subject is presented and to the spirit in which the book is written, there is no gainsaying the fact that Nernst is an ex-

tremely able man and that his book contains a great deal of valuable information. The mere fact that it has been through seven German editions is proof in itself that people read it. There is a fine sound to the subdivisions of the book: the universal properties of matter; atom and molecule; the transformation of matter; the transformation of energy. What could be better than this? When a man sandwiches a chapter on colloidal solutions in between one on radioactivity and one on the absolute size of the molecules, one is almost tempted to forgive him for talking about the enormous molecular weights of substances in the colloidal state. In a great many chapters what Nernst has to say is very well worth while and of course it is not fair to read the parts on colloid chemistry, photochemistry, and flame spectra in the light of what one now knows. It is possibly the war, though I think not; but the whole tone of Nernst's book grates on one, perhaps more when it is presented in English than when one reads it in German. The contrast between this book and van't Hoff's Lectures is very striking.

The translation is very much better done than has been the case in most of the previous English editions. Either the translator or the proofreader has been very careless, however, in regard to proper names, many of which are misspelled.

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SPECIAL ARTICLES

THE MEASUREMENT OF LIGHT IN SOME OF ITS MORE IMPORTANT PHYSIOLOGICAL ASPECTS

The principal relations of light to organisms include the following phases of its action:

1. Photosynthesis, in which specialized protoplastic masses containing chlorophyll elaborate carbohydrates from carbon dioxide and water. The well-known absorption bands of chlorophyll in the red and in the blue are taken to indicate the portions of the spectrum concerned in this action.

2. Influence of illumination on transpiration and water content. It is probable that the red end of the spectrum chiefly furnishes the wave-lengths which cause changes in temperature, and variations in water loss.

3. Influence of illumination on the respiration and other metabolic processes in protoplasm as induced by the photolysis of substances important to the life of the organism.

4. Coagulatory, neutralizing or disintegrating action of light or toxic effect of products, especially of the shorter wave-lengths, on living matter as exemplified by the fatal effects of blue-violet rays on minute organisms.

5. Tropistic reactions, in which the position of the axes or of the entire body is changed in response to direction or intensity of the rays and with respect to special wave-lengths. Various parts of the spectrum may be active in different organisms.

6. The indirect action of light on rate, course and amount of growth, together with morphogenic reactions. Such effects have not yet been analyzed to an extent which might furnish data for a rational discussion of the direct effects of light on growth. Indirect effects are recognizable.

7. Action of light on environic conditions exemplified in the ionization of the air by the shorter wave-lengths as described by Spoehr.

Experimentation upon any of these subjects requires sources of light under good control, screens for transmitting special regions of the spectrum and methods of measurement of the relative intensity of the illumination falling on the organism.

Sunlight may serve in some work when the requisite screens are available, but incandescent filaments, mercury and amalgam vapor arcs enclosed in glass or in quartz may be used as sources of light down to wave-lengths of .28 μ.

Layers of liquid, pigments in gelatine and other perishable screens have served admirably in some demonstration and research work, but when long-continued exposures to intensities approaching those of normal sunlight are desired a durable screen is necessary. A series of formulæ for a number of glasses which would transmit various parts of the spectrum has been developed in the laboratory of a prominent firm of glass-makers. These may

now be obtained in stamped plates $6\frac{1}{2} \times 6\frac{1}{2}$ inches.

A brief characterization of a few of these is given below:

Red: High transmission in red removes all light below .61 μ.

Blue: Transmits only blue below .52 μ and may be made deeper to transmit only below .50 μ.

Yellow: High transmission in red and infra-red and through green to .48 μ giving about 75 per cent. of incident white light. All ultra-violet absorbed.

Uviol: Transparent to visible spectrum, transmitting ultra-violet to .31 μ in sheets $\frac{1}{4}$ inch thick, to 30 μ through $\frac{1}{8}$ inch thick.

Heat-Absorbing: Absorbs most of infra-red and 97 per cent. of heat of Nernst lamp—gives a pyrheliometer reading about half that of good window glass. Transmits 65 per cent. of incident white light.

Formulæ of twenty other glasses are available by the use of which the regions of the spectrum noted above may be modified or different separations made. Desirable effects may also be obtained by combination of two screens. Thus for instance light passing through a yellow of the type described above and the heat absorbing glass loses all the spectrum except the yellow and a small part of the red.

The only thoroughly reliable measurements of solar radiation available to the biologist are those made with the Ångström and Abbot type of pyrheliometer which recorded the total normal insolation in heat units. However, in the blue-violet region of the spectrum, which is of especial interest to the biologist, this type of instrument is not sufficiently sensitive. It is therefore proposed to use the *photo-electric cell* as developed by Elster and Geitel. This instrument has the great advantages of extreme sensitiveness in the blue-violet region and ease of manipulation; it records immediate and directly proportional values, and can be used for extensive ranges of intensities.

A comparison of the results to be obtained by the use of the two methods is afforded by the data given below. Direct sunlight at the Desert Laboratory is taken as 100, and the figures in both cases are percentages of this total. The values from the pyrheliometer were calculated in calories per sq. cm. per minute, and those of the sodium photo-electric cell are from readings of the high sensitvity galvanometer.

Illumination	Proportion of Direct Sunlight (Sunlight = 1.39 Calories per Sq. Cm. per Minute) Smithsonian Pyrheliometer Values	Sodium Cell Values
Direct sunlight at	100%	100%
Transmission—		
Uviol glass	90.2%	86.6%
Yellow glass	53.6%	5.1%
Red glass	42.4%	0.62%
Heat-absorbing glass.	25.4%	63.2%
Blue glass	10.5%	49.0%

These results show a total value of normal sunlight through *uviol* glass transmitting the entire spectrum not being widely different by the use of the two instruments, although the pyrheliometer values are derived from the longer wave-lengths and those of the sodium cell from the shorter ones.

It may be assumed that half of the total energy registered by the pyrheliometer is strictly within the red, which causes but little action in the sodium cell.

The pyrheliometer shows a total of nearly 54 per cent. of the energy of sunlight passing through the yellow screen which transmits from red to and including the blue-violet.

Perhaps the most interesting results are those which are obtained by measurement of light passed through the so-called heat-absorbing screen, which has been found to transmit the visible spectrum except the longer red and infra-red.

The pyrheliometer reading of such a glass is but 25 per cent. of clear sunlight, while the sodium cell records 63.2 per cent. of the total. A notable difference between the recording action of the two instruments in the blue is also evident. It is self-evident that the universal method of calibration of sunlight intensities by the pyrheliometer does not give results which are adequate or correct in all of the various aspects of the physiological effects of light.

Measurement of light from artificial sources has been done chiefly by photometric methods, but it is to be pointed out that the results obtained in this manner are scarcely more adequate than those of the pyrheliometer.

The sodium cell connected with a suitable portable galvanometer offers many advantages for the measurement of light intensities in natural habitats, and a comparison should be made between it and the various photometers and illuminometers which are now being recommended to the forestry student and the ecologist. It seems highly probable that more exact measurements in the blue-violet region so important in photolysis and phototropism will yield information by which some of the current discordant results may be harmonized. In any case the action of the photoelectric cell in light is more nearly parallel to that of the organism than that of any other light measuring instruments hitherto available.

We are indebted to Professor Jacob Kunz, of the University of Illinois, who has very kindly constructed some cells to meet our particular needs and whose advice has been most helpful in the application of this instrument to physiological uses.

D. T. MacDougal,
H. A. Spoehr

Desert Laboratory,
Tucson, Arizona,
March 30, 1917

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 569th regular meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, April 7, 1917, called to order at 8 P.M. by President Hay with 45 persons in attendance.

Under the heading brief notes and exhibition of specimens Dr. R. W. Shufeldt exhibited lantern slides of living California quail, calling attention to their rapidly diminishing numbers. Dr. L. O. Howard called attention to the cocoon of a *Cecropia* moth containing moon-stones that had lately come to his notice. He expressed the opinion that they had been placed there by a thieving crow or bluejay. Mr. A. Wetmore stated in this connection that he had seen bluejays insert small acorns and kernels of corn into large cocoons.

The regular program consisted of two communications:

A Note on the Hibernation of the Mud-turtle: Alexander Wetmore and Francis Harper.

The authors reported finding a specimen of *Kinosternon pennsylvanicum* shortly after it had left its underground winter-quarters. The hole from which it had emerged was beneath a dense growth of green-briar in an old field and about fifty yards from the nearest marsh. The burrow was 9½ inches deep, and was open save at the lower end, where the animal had apparently lain encased in a mass of mud. The actions and conditions of the turtle after being placed in water were described in detail, and an account of a post-mortem examination of the viscera was given. Messrs. W. P. Hay, M. W. Lyon, Jr., and Wm. Palmer took part in the discussion.

Botanizing in the Hawaiian Islands: A. S. Hitchcock.

The speaker visited the Hawaiian Islands during five months of 1917. He said the trade winds deposit their moisture upon the eastern and northern mountains of all the islands, furnishing the conditions for rain forests in these regions. The lee side of the islands is dry even to aridity. An interesting feature of the wet areas at or near the summit of the ridges are the open bogs. These bogs are devoid of trees and large shrubs, but contain a variety of low shrubs and herbaceous plants. Many species form tussocks, or hemispherical masses raised above the level of the bog. The most conspicuous of the tussocks is made by a sedge (*Oreobolus furcatus* Mann.). Three peculiar species of *Panicum* are tussock-formers (*Panicum monticola* Hillebr., *P. imbricatum* Hillebr. and *P. isachnoides* Munro). Owing to the extreme isolation of the islands the flora is peculiar and interesting. The family Lobeliaceæ is represented by about 100 species, belonging to about 6 genera. Many species are arboreous, forming trunks ten to twenty feet, or in a few cases as much as forty feet high. The crown of foliage gives the aspect of a palm. The grasses, disregarding the introduced species, are not numerous, but several are peculiar. The genus *Eragrostis* is represented by numerous species. A rare species of *Poa* (*Poa siphonoglossa* Hack.) produces leafless rushlike stems, as much as fifteen feet long. His talk was illustrated by maps, botanical specimens and numerous lantern-slide views of various features of the islands.

M. W. Lyon, Jr.,
Recording Secretary